Climatological Data for June, 1910.

DISTRICT No. 9, COLORADO VALLEY,

FREDERICK H. BRANDENBURG, District Editor.

GENERAL SUMMARY.

Low pressure and a practically stagnant atmosphere exerted the controlling influence on the weather conditions of the month, and the hot, dry weather, characteristic of June, prevailed scarcely without interruption. Except in a few localities, temperatures were above the normal during the first 12 days, with marked excesses throughout the district, and in Arizona again on the 10th and 11th. During the remainder of the month the weather was somewhat cooler in the southern half, and in general it was warmer than normal in the northern half of the district, except during the last 3 days, which were relatively cool throughout the district. While scattering showers fell near the beginning of the month, the amounts and areas covered were too small to be of practical benefit to the ranges or to increase the discharge of the smaller streams, the flow from which had become inadequate for the needs of irrigation. Range grass remained very short and stock was suffering from the effects of the prolonged dry period. The drought, however, was somewhat relieved in most localities near the close of the month.

TEMPERATURE.

The mean temperature of the 125 stations reporting was 70.7°, or 0.9° above the normal. By subdivisions the means and departures were: Western Wyoming, 59.1°, +5.6°; western Colorado, 60.5°, +2.3°; eastern Utah, 66.8°, +3.5°; western New Mexico, 70.8°, +0.8°; Arizona, 78.5°, −0.3°. The highest monthly mean was 93.0° at Mohawk Summit, Ariz.; the lowest, 49.2°, at Fraser, Colo. The extremes were: 120° at Gila Bend and Mohawk Summit, Ariz., on the 10th, and 20° at Silverton, Colo., on the 22d. In western Wyoming the maximum reached 95°; in the valleys of western Colorado, 98°; and in eastern Utah, western New Mexico, southeastern Nevada, and Arizona readings considerably above 100° were noted at many stations.

PRECIPITATION.

The average precipitation for the 170 stations reporting was 0.56 inch, or 0.06 inch above the normal. By watersheds the means and departures were: Green, 0.46, −0.32; Grand, 0.58, −0.20; San Juan, 0.69, +0.01; Little Colorado, 0.53, +0.12; Gila, 0.52, +0.13; Mimbres, 0.99, +0.46; Colorado, proper, 0.51, +0.31. The greatest monthly amount was 4.00 inches at Baker, Utah, while none fell at 7 stations in Arizona and 2 in Nevada. On an average there were 2 days with 0.01 inch or more of precipitation.

Heavy showers over a small area in Paradise Valley, 18 miles north of Phoenix, during the afternoon and evening of June 27, caused the washing out of the large Arizona canal in 21 places in the distance of 1 mile, and caused a rise in the Salt River at Tempe of several feet. Some of the low lands in Paradise Valley, adjacent to Salt River, were badly eroded.

MISCELLANEOUS.

The amount of sunshine was extraordinary: Durango reported 88 per cent of the possible; Grand Junction, 89 per cent; Flagstaff, 92 per cent; Phoenix, 96 per cent; and Yuma, 99 per cent. The relative humidity was 40 per cent or lower.

There were a number of high winds and sandstorms, but the damage was not great.

THE WATER-POWER RESOURCES OF COLORADO, WITH SPECIAL REFERENCE TO STREAM FLOW.

By W. B. FREEMAN, District Engineer, U. S. Geological Survey.

For an intelligent discussion of the conservation of the water resources of Colorado it is quite important to know the amount and value of these resources. In this paper I will attempt to show first the total run-off or flow of our streams and rivers, and, secondly, the amount of water power which it will be possible to derive from them. The State has been divided into the following drainage basins, which include the streams named and their tributaries in Colorado: The Arkansas River; the South Platte River; the North Platte (Republican); the Rio Grande; the Green River, which embraces the White; the Grand River, including the Dolores and Gunnison; and the San Juan River.

RUN-OFF OF COLORADO STREAMS.

Records of stream flow, extending over periods of from 1 to 20 years, have been obtained on some of the streams in each of the drainage basins outlined above, from which it is impossible to make estimates of the total flow. Some time ago I made a study of this total run-off, with a view to determining the amount of run-off water which actually reached our streams. In this study I made the assumption that natural conditions existed; that is, the conditions which obtained before the settlement of the country and the construction of irrigation and other hydraulic work. Neglecting possible changes which may have been made in the average rate of run-off by cultivation, grazing, and deforestation, the average run-off should be the same now as it was at that time. These figures do not exactly represent the amount of water which would actually leave the State if no water were used, because no allowance has been made for evaporation and other losses. In a great many cases they are very approximate because of the inadequacy of stream measurements. I think, however, they are of considerable value as showing the relative size of our stream systems.

TABLE 1.—*Estimated mean annual run-off of rivers in Colorado.*

Stream system.	Annual run-off.
	Acre-feet.
Arkansas River and tributaries in Colorado	1,600,000
Cimarron River and tributaries in southeastern Colorado	10,000
Grand River, including Dolores-Gunnison, in Colorado	6,500,000
Green River drainage in Colorado	2,000,000
North Platte River and tributaries in Colorado	600,000
Republican River and tributaries in Colorado	30,000
Rio Grande River and tributaries in Colorado	1,100,000
San Juan River and tributaries in Colorado	2,400,000
South Platte River and tributaries in Colorado	1,400,000
Total in Colorado	15,640,000

It will be noted that of this total average of 15,640,000 acre-feet per annum, the eastern slope, with a drainage area of 65,000 square miles, or 63 per cent of the total area of the State, yields but 4,750,000 acre-feet, or 30 per cent of the total; while the western slope, with an area of 38,700 square miles, yields 10,900,000 acre-feet, or 70 per cent of the total. The average rate of run-off for the State is 150 acre-feet per square mile per annum, equivalent to a depth of 3 inches over the entire surface. The rate for the western slope is 280 acre-feet per square mile per annum, equivalent to a depth of 5⅓ inches; and for the eastern slope it is 73 acre-feet per square mile per annum, or a little over 1¼ inch. This large difference between the rates of run-off on the two sides of the Continental Divide is easily accounted for when it is considered that there is very little area on the western slope below an elevation of 6,000 feet, and a great deal of it is between 10,000 and 14,000 feet high, while fully one-half the eastern drainage area is at an elevation of 5,000 feet or less. Moreover, in the high mountains the run-off is usually greater for the western than for the eastern slope.

There is a very large drainage area in eastern Colorado which is practically nonproductive as to run-off, so that the average depth of run-off over the area on the eastern side of the mountains is probably more nearly 2 inches for the portion which is

productive of run-off. Table 2 gives the area of watershed and the average annual depth of run-off in inches for the various watersheds in Colorado. An inch in depth is equivalent to a rate of about 53 acre-feet per square mile per annum.

TABLE 2.

Drainage basin.	Drainage area.	Depth of run-off annually.
	Sq. mi.	*Inches.*
Arkansas	25,000	1.2
Cimarron	3,000	0.06
Grand	23,000	5.6
Green	11,000	3.4
North Platte	1,900	6.0
Republican	8,000	0.07
Rio Grande	7,700	2.7
San Juan	5,700	8.0
South Platte	19,400	1.4

An average annual run-off as great as 30 inches and over has been recorded in the high mountains, particularly at the headwaters of the San Juan River. On the other hand, there are large areas where it is less than one-half inch and where it would require 40 square miles of drainage area to produce enough water to irrigate one section of land. If this fact were more generally known it might serve to check some of the numerous "wildcat" irrigation schemes in this State, which have no basis whatever for existence. There are too many opportunities for legitimate irrigation development.

About 2,000,000 acres of land are now being irrigated in Colorado on the eastern side of the Continental Divide. With proper conservation of the water supply this acreage should be nearly doubled. On the western slope there are probably less than 500,000 acres of irrigated land, while there is water enough to irrigate 7,000,000 acres. A very considerable percentage of this acreage is available for irrigation, though it will never be possible to utilize all of the waters of the Grand River proper, or a very large percentage of the waters of the San Juan, to irrigate Colorado land. It is believed that at least 8,000,000 acres of land should eventually be irrigated in this State, or three times the amount that is now under irrigation.

POWER RESOURCES OF COLORADO.

In connection with the report to the Conservation Commission in 1908, the U. S. Geological Survey compiled figures on the water-power possibilities of this State under existing conditions with reference to irrigation. Use was made of the best maps and data available, and the figures are considered fairly accurate. In this compilation the average low water flow during the 6 high months of the year was taken as a basis, and the amount of power which the different streams could develop with this minimum was determined. In other words, a water-power plant could operate with a maximum capacity equal to this minimum for 6 months each year. Then, if there were no storage for the equalization of the flow, the plant would either have to shut down or operate at a capacity of less than the maximum for the remaining 6 months.

The storage facilities along the various streams were also investigated, and an estimate made of the amount of power which it would be possible to develop from storage during the 6 months' period over and above the amount derived from the minimum flow during the 6 high months. The stored waters could be released as needed, and it is fair to assume that they would be used to augment the natural flow during the 6 low-water months; thus, in many cases, making the average for that period as much or more than the minimum for the 6 high months.

The minimum flow of a stream during a year determines the minimum power or primary power which can be developed, and a power plant can furnish this amount of power continuously without storage. In Table 3 the minimum power considered is the average minimum for a 7-year period, and the minimum for a year was computed from the average flow for the lowest 14-day period during that year. This table shows the power possibilities of the State divided into the drainage areas outlined at the beginning of the paper. The horsepower computations were made on the assumption that 90 per cent of the total fall could be utilized, and that the efficiency of the water wheels would be 80 per cent.

TABLE 3.—*Estimated horsepower of rivers in Colorado.*

	Minimum.	Minimum for 6 high months.	From storage during a period of 6 months.
Arkansas River and tributaries in Colorado	102,800	176,000	312,600
Cimarron and tributaries in Colorado			
Grand River, including Dolores-Gunnison in Colorado	456,000	857,000	1,274,000
Green River drainage in Colorado	75,700	205,500	455,000
North Platte River and tributaries in Colorado	5,200	13,900	12,800
Republican River and tributaries in Colorado			
Rio Grande River and tributaries in Colorado	46,700	75,500	55,500
San Juan River and tributaries in Colorado	54,600	113,500	115,200
South Platte River and tributaries in Colorado	87,400	231,700	335,100
Total in Colorado	828,400	1,673,100	2,560,200

The total minimum or primary horsepower is 828,400, of which 586,300, or 70 per cent, is on the western slope; the minimum for the 6 high months is 1,673,100, 70 per cent of which is on the western slope; and the horsepower from storage during the 6 months' period is 2,560,200, 72 per cent of which is on the western slope. It is rather a noteworthy fact that the western slope can furnish the same percentage of the total power as it does of the total stream flow of the State, but of course irrigation has not interfered with possibilities for power development on that slope to the same extent as it has on the eastern slope. It will be noted that just about 50 per cent of the water horsepower available in the State is to be found in the Grand River system.

Combining the minimum horsepower for the 6 high months with the horsepower from storage during a 6-month period, we obtain 2,117,000 horsepower as the average continuously available. It is believed that it will be possible eventually to utilize 1,000,000 horsepower by harnessing the streams of this State without interfering with the use of water for irrigation purposes. On the assumption that 20 tons of coal per year are required to produce 1 horsepower, the development of this amount of water power will some day mean a saving of 20,000,000 tons of coal annually, or twice the amount which was mined in the State in 1908. At the present time it is likely that it will be practicable to save 3,000,000 tons per year, with the value at the mines of over $4,000,000, by the use of water power. It is not known what the relative advantage of water is over steam power in this State. On the assumption that it is only $10 per horsepower per annum, there should be a saving of at least $2,000,000 a year if water power were used to the extent that it should be.

The census of 1908 shows that there were 353 water wheels in the State, with a total capacity of 78,878 horsepower. The figures of the U. S. Geological Survey, compiled in the same year, show that there were probably less than 50 plants in the State with a capacity of 50 horsepower or over, and that the total actual water power development amounted to about 50,000 horsepower. Since then a few plants have been completed, most notably, the Shoshone Plant of the Central Colorado Power Company. It is safe to say that the total is still less than 100,000 horsepower, which is 10 per cent of the total possible.

Resume.—When the irrigated area of the State is increased 3 times and 10 times the present water power development made possible, Colorado will still have some chance to conserve her water power—her greatest natural resource. There seems to be abundant opportunity for beneficial legislation, both State and National.